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1999/09/02 : CIA-RDP79-01093A001200120009-4

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PROVISIONAL INTELLIGENCE REPORT

SURVEY OF SELECTED PLASTICS IN THE SOVIET BLOC



CIA/RR PR-163

31 May 1957

CENTRAL INTELLIGENCE AGENCY

OFFICE OF RESEARCH AND REPORTS

DOCUMENT NO. 1
NO CHANGE IN CLASS. ☐

CI DECLASSIFIED

CLASS. CHANGED TO: TS 9 (C)

DATE: 13/11/79
AUTH: HR 70-2

Approved For Release 1999/09/02 : CIA-RDP79-01093A001200120009-4

DATE: 13/11/79 REVIEWER: 019360

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SURVEY OF SELECTED PLASTICS IN THE SOVIET BLOC

CIA/RR PR-163

(ORR Project 22.1568)

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FOREWORD

The plastics industry in the Soviet Bloc has grown to major proportions since World War II, and its products are used in almost every phase of industry and military defense. The subject is covered most effectively by presenting information about the two plastics which have the greatest production and application in the Bloc: phenolics and polyvinyl chloride. A whole range of products, from electrical fittings to gun stocks and from sheeting to plastic pipe, are made from these two plastics. Except for those cases where significant data are available, this report does not attempt to cover the field of fabricated products. A later report will discuss the numerous types of plastics which have more specialized uses and important strategic applications but are not now produced in large quantities in the Bloc.

Production in Communist China, where the plastics industry is still in its infancy, is not discussed in this report. Chinese Communist production is insignificant, consisting only of a small amount of phenolics, used chiefly for making electrical fittings.

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SURVEY OF SELECTED PLASTICS IN THE SOVIET BLOC*

Summary

The Soviet Bloc emphasizes the industrial and military applications of plastics** rather than their use in consumer goods. Plastics are valuable largely because they can be used to replace scarce metals or to achieve greater efficiency or economy.

The major producers of plastics in the Soviet Bloc are the USSR and East Germany. The plastics produced in largest volume are phenolics and polyvinyl chloride.

The USSR produced only 12,500 metric tons*** of plastics in 1940, but production had increased by 1955 to about 84,000 tons, including 38,700 tons of phenolics. In comparison, the US produced about 126,000 tons of plastics in 1940 and 1,590,000 tons in 1955, including 229,500 tons of phenolics. Plastics comprise 3.0 to 3.5 percent by value of total Soviet production of chemicals. The value of plastics produced in the US is about 7.8 percent by value of total chemical sales. Only 14 percent by value of plastics produced in the USSR in 1954 went into consumer goods, and 86 percent went into producer goods, including military items. The major portion of plastics produced in the US goes into consumer goods.

In East Germany, production of plastics rose from fewer than 7,000 tons in 1947 to about 58,000 tons in 1953, including 36,700 tons of polyvinyl chloride.

* The estimates and conclusions contained in this report represent the best judgment of ORR as of 15 March 1957.

** Unless otherwise indicated, the term plastics as used in this report refers to such materials as resins and molding powders rather than to fabricated articles.

*** Tonnages are given in metric tons throughout this report.

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Production of plastics in the other European Satellites is small. Czechoslovak production in 1953 was about 16,300 tons, and in Poland about 11,000 tons were produced in 1954. In the other Satellites, production is on a pilot-plant or semicommercial scale. Plans have been published which stress the increased production of polyvinyl chloride during the next 5 years. Planned production of all types of plastics and of polyvinyl chloride in the Soviet Bloc in 1960 is shown in Table 1.

Table 1

Planned Production of Plastics in the Soviet Bloc
1960

Country	Polyvinyl Chloride	Metric Tons
		Total
USSR	N.A.	209,000
East Germany	72,000	N.A.
Other Satellites		
Czechoslovakia	9,000	N.A.
Hungary	6,000	11,600
Poland	18,000	52,500
Rumania	10,500	16,000
Total	<u>43,500</u>	<u>80,100 a/</u>
Grand total	<u>115,500 b/</u>	<u>289,100 a/</u>

a. Production in East Germany and Czechoslovakia may add considerably to total production.

b. Production in the USSR may add considerably to total production.

Major efforts will be made in the future to produce specialized plastics for defense and industrial use which meet demands for materials that are more resistant to high pressure, corrosion, and extremes of heat and cold. The trend in production of consumer goods will be toward multipurpose plastics with low costs of production.

East Germany is the major exporter of plastics in the Soviet Bloc, exporting chiefly polyvinyl chloride. At least 50 percent of the polyvinyl chloride exported by East Germany goes to the USSR, apparently

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at prices below those which the European Satellites must pay. East German exports of polyvinyl chloride to non-Bloc countries often have been at prices below those offered by US producers. Plans to increase production of plastics in the Soviet Bloc depend on the availability of increased quantities of raw materials and also, to some extent, on the receipt of equipment and technology from the West. The Bloc is dependent on the West for equipment and technology used in producing polyethylene, fluorocarbons, and silicones, which are plastics with strategic uses in jet aircraft, missiles, and nuclear energy.

Production of plastics in the Soviet Bloc is potentially vulnerable because of the concentration of production in a few large plants. Stoppages of production at 1 major plant in East Germany and at 2 plants in the USSR would almost halt production of polyvinyl chloride.

The military intentions of the Soviet Bloc cannot be gauged by its developmental plans for polyvinyl chloride or phenolic resins, because these plastics have extensive consumer and industrial applications in addition to their military uses.

I. Introduction.

Plastics have been defined as "a large and varied group of materials which consist of, or contain as an essential ingredient, an organic substance of large molecular weight which, while solid in the finished state, at some stage of its manufacture is made liquid, and thus capable of being formed into various shapes, mostly through the application, either singly or together, of heat and pressure." 1/* There are two distinct classes of plastics, thermosetting resins and thermoplastic resins. Thermosetting resins are hard and brittle, and usually when once fabricated they cannot be reformed with the application of heat and pressure. Thermoplastic resins may be either hard or soft and can be reshaped repeatedly by heat and pressure. The manufacture of plastic materials is a chemical process and is distinct from the fabrication of plastics into

* For serially numbered source references, see Appendix D.

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finished articles, but the two operations may be carried out in a single plant. In the US the manufacturer of plastics seldom makes finished consumer goods but rather sells the plastics in the form of sheets, rods, tubes, flakes, powder, or liquid to the fabricator. A more detailed discussion of the various types of plastics and their applications is given in Appendix A. US experience during World War II, when more than 85 percent of its production of plastics was used for military purposes, 2/ showed that plastics often could be substituted for metals which were in critically short supply and that they frequently were more satisfactory under conditions of severe service than the metals which they replaced. Modern weapons such as supersonic aircraft, guided missiles, and electronic devices require the extensive use of plastics in their components. In addition, the use of plastics to replace metals, wood, and other materials in a wide variety of industrial goods and consumer goods explains the phenomenal growth of the plastics industry. The special qualities of plastics which make this substitution desirable include lightness, resistance to corrosion, stability at normal temperatures, high tensile and impact strength, ease of molding, and low cost. A material can be made from the various types available which has the special properties needed to meet a specific application.

During the past 30 years the plastics industry has had a consistently rapid growth in most countries because of the increasing use of plastics in consumer goods. In the US the plastics industry is expected to expand almost twice as fast as the entire chemical industry and five times as fast as US industry as a whole. 3/ Production increased from less than 6 million pounds in 1922 to 3.5 billion pounds in 1955, 4/ equal in value to US \$1.8 billion.* 5/ Chemical sales during 1955 were slightly over \$23 billion, and the value of plastics produced** represented about 7.8 percent of the value of all chemicals sold. 6/

Consumption of plastics per capita in most Soviet Bloc countries has been at a considerably lower level than in the US or Western Europe. In the Communist countries the use of plastics in consumer goods has been small, and emphasis has been placed on the use of plastics in heavy industry and in armaments. The USSR and East Germany are the major producers, but the other members of the Bloc have scheduled

* Dollar values are given in US dollars throughout this report.

** The value of plastics produced exceeds the value of sales of plastics. The value of production is given to facilitate comparison with Soviet figures.

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a rapid expansion of the industry during the next 5 years. At present the two types of plastics made in volume in the Bloc are phenolics and vinyls.

Although the Soviet Bloc makes small amounts of the more complex types of plastics, production is still in the laboratory and development stages. In general, the technology of the Bloc in the field of silicones, fluorocarbons, and epoxy resins is about 5 years behind that of the US, and manufacturing lags by about 10 years. The USSR, Czechoslovakia, Hungary, and Rumania are attempting to obtain process data, manufacturing techniques, and equipment from the Western countries for the critical types of plastics. 7/ Should they be successful in these efforts, the existing time lags would be sharply reduced. The Communist efforts to accelerate production are understandable in view of the important applications of these materials in the development of radar, supersonic aircraft, and guided missiles.

II. USSR.

A. General.

The USSR is fully aware of the importance of using plastics to replace critical materials, not only to economize on the use of ferrous and nonferrous metals but also to improve performance, lower requirements for labor, and reduce the cost of finished articles. The Minister of the Chemical Industry recently pointed out that 1 ton of polyvinyl chloride for electrical insulation replaces about 5 tons of lead and that the use of synthetic resins in production of precision castings reduces the consumption of metal by 15 to 20 percent and increases the productivity of labor by 30 percent. 8/ The minister added that the manufacture of modern, high-speed aircraft and new developments in the electrical and radar fields are impossible without new synthetic materials which are resistant to high and low temperatures.

The Soviet Ministry of the Machine Tool and Instrument Industry announced that plastics will comprise 20 percent of the weight of metal-cutting machine tools in the next few years and that during 1956 the machine tool industry was to use more than 700 tons of plastics, thus saving 5,000 tons of metal. 9/ The savings in labor and cost resulting from the use of plastics in the USSR are shown by the following published data on the results of substituting plastics for metals in certain articles 10/:

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<u>Article</u>	<u>Labor required was formerly</u>	<u>Cost of article was formerly</u>
Bushing	2.8 times greater	2.8 times greater
Thrust screw	2.1 times greater	2.0 times greater
Magnifying glass frame	5.0 times greater	3.0 times greater
Housings	7.8 times greater	5.7 times greater

B. History.

Plastics partially replaced metals in aircraft, tanks, and other armaments in the USSR during World War II. 11/ Production of plastics was expanded during the war to meet military requirements, and after the war the expansion of existing plants and the construction of new facilities continued under the Fourth Five Year Plan (1946-50). In addition to the expansion of production of conventional plastics, since 1945 the USSR has expanded its programs for research and development in some of the newer and more specialized plastics. Production of such plastics as fluorocarbons, silicones, and polyethylene is believed to be still on an experimental or a low-volume basis.

The plastics industry in the USSR is controlled by the Main Administration of Chemical Plastics and Paints (Glavkhimplastkraska) in the Ministry of the Chemical Industry.

C. Production.

Production of plastics in the USSR has shown a steady increase since 1940, but large-scale production has been confined to a narrow range of products because of limitations in raw materials, technology, and processing equipment.

The USSR produced about 12,500 tons of plastics in 1940* and about 84,000 tons in 1955. Soviet production is about 5 percent of US production and is scheduled to increase more than 2.5 times under the Sixth Five Year Plan (1956-60). 12/ A comparison of estimated production of plastics in the USSR and in the US in 1940 and 1950-55 and planned production in 1960 is shown in Table 2.**

* For methodology, see Appendix B.

** Table 2 follows on p. 7.

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Table 2

Estimated Production of Plastics in the USSR and the US a/
1940 and 1950-55

<u>Year</u>	<u>Metric Tons</u>	
	<u>USSR</u>	<u>US <u>b/</u></u>
1940	12,500	126,000 <u>c/</u>
1950	34,700 <u>d/</u>	1,000,000
1951	45,100 <u>e/</u>	1,110,000
1952	55,500 <u>e/</u>	1,091,000
1953	65,900 <u>f/</u>	1,318,000
1954	74,800 <u>g/</u>	1,364,000
1955	83,600 <u>h/</u>	1,590,000
1960	209,000 <u>i/</u>	2,727,000 <u>j/</u>

a. For methodology, see Appendix B.

b. 13/

c. 14/

d. Plan figure. 15/

e. Estimated on the basis of production in 1950 and 1953.

f. 16/

g. Estimated by interpolation.

h. Plan figure. 17/

i. Plan figure. 18/

j. Estimated. 19/

Phenolics are the principal products of the Soviet plastics industry in terms of volume produced. They are usually produced in the form of molding powders and are used in the electrical and the communications industries, in the manufacture of airplane and automobile parts, in glues, and in lacquers. Estimated production of phenolics in the USSR in 1950-55 is shown in Table 3.*

* Table 3 follows on p. 8.

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Table 3

Estimated Production of Phenolics in the USSR a/
1950-55

<u>Year</u>	<u>Amount</u> <u>(Metric Tons)</u>
1950	19,700 <u>b/</u>
1951	22,550 <u>c/</u>
1952	25,800 <u>c/</u>
1953	29,550 <u>d/</u>
1954	33,800 <u>e/</u>
1955	38,700 <u>f/</u>

- a. In terms of molding powders, which contain about 50 percent resin and 50 percent filler. For methodology, see Appendix B.
- b. Plan figure. 20/
- c. Estimated on the basis of production in 1950 and 1953.
- d. 21/
- e. Estimated by extending the figures for 1950-53.
- f. Estimated by extending the figures for 1950-53. The estimate may be low in view of the anticipated expansion of facilities for production at the Karbolit Plant in Kemerovo in 1955. 22/ By contrast, US production of phenolics in 1955 was about 229,500 tons. 23/

The principal producer of phenolics in the USSR is the Karbolit Plant located at Orekhovo-Zuyevo (55°49' N - 38°59' E), which was reported to have produced 40 percent of Soviet production of plastics before World War II. 24/ The locations of the phenolics plants in the USSR and the approximate year in which these plants went into production are shown in Table 4.*

* Table 4 follows on p. 9.

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Table 4

Phenolics Plants in the USSR a/

Plant Name	Location	Coordinates	Economic Region <u>b/</u>	Start of Plastics Production
Karbolit Plant	Orekhovo-Zuyevo	55°49' N - 39°02' E	VII	1915
Chemical Plant No. 96 (Stroy)	Dzerzhinsk	56°15' N - 47°37' E	VII	1947
Chemical Plant No. 154 (Koshalya)	Vladimir	56°10' N - 40°25' E	VII	1937
Karbolit Plastic Plant	Kemerovo	55°17' N - 86°03' E	IX	1943
Okhta Chemical Combine <u>c/</u>	Leningrad	58°05' N - 30°29' E	Ia	1924

a. 25/

b. The economic regions are those defined and numbered on CIA Map 13702 (4-55), USSR: Administrative Divisions and Economic Regions, January 1955.

c. 26/

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Of the vinyl resins, the USSR is known to produce polyvinyl chloride and small amounts of chlorinated polyvinyl chloride, polyvinyl acetate, and polyvinyl butyral. 27/ Polyvinyl chloride is produced at Chemical Plant No. 96 in Dzerzhinsk 28/ and at Plant No. 91 in Beketovka. Production at Plant No. 96 is based on the installation moved from Bitterfeld in East Germany. Production in 1949 was estimated at 5,000 to 6,000 tons. 29/ Production at Plant No. 91 was reportedly 7,000 tons in 1955, but information is insufficient to confirm this figure. 30/ For this reason an over-all estimate of production of polyvinyl chloride cannot be made on the basis of available data.

Polyvinyl acetate has been made at the Polyvinyl Acetate Plant in Yerevan (40°11' N - 44°30' E) since about 1953. 31/ The USSR was planning a major expansion of production of vinyl acetate at this plant in 1956 and 1957. 32/ This expansion may not result in a corresponding increase in polyvinyl acetate available for sale, however, because vinyl acetate is used to make polyvinyl alcohol, which is needed in making polyvinyl butyral, an important interlayer material in safety glass for military aircraft. At the Yerevan plant, production of polyvinyl butyral, believed to have been negligible in 1956, is scheduled to be expanded under the Sixth Five Year Plan. 33/

D. Value of Production.

The estimated value of plastics produced by the Ministry of the Chemical Industry in the USSR in 1954 is 661 million rubles.* 34/ Of this amount, plastics which were produced as chemical raw materials accounted for 443 million rubles, and plastics which were produced in the form of finished articles accounted for 218 million rubles.** 35/

The value of Soviet production of chemicals in 1954 is estimated at about 20 billion rubles,*** of which plastics accounted for 3.0 to 3.5 percent.

* Expressed in prices of 1954. The official rate of exchange of 4 rubles to US \$1.00 is not necessarily an accurate reflection of the dollar value.

** Believed to include the value added in fabrication.

*** For methodology, see Appendix B.

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E. Labor and Mechanization.

The USSR is vitally interested in using modern equipment for fabricating plastics into finished articles, but such equipment has not always been available. Lack of sufficient mechanization has been reflected in high labor inputs in the fabricating sector of the Soviet plastics industry. In 1954 the reworking of plastics into finished articles occupied 70 percent of the workers in the plastics industry, although finished articles comprised only 33 percent of the total value of plastics produced. 36/

To overcome deficiencies in equipment, the USSR has put into operation injection molding machines of domestic origin with capacities of 30, 250, 500, and 1,000 grams of casting per cycle and has been converting hydropresses with manual control to semiautomatic operation. 37/ Continued industrial expansion and expansion of the market for consumer goods will require further mechanization of production of plastics. The Soviet desire to mechanize production of plastics has already been reflected in efforts to obtain equipment and technical knowledge from the West. 38/

The USSR planned to increase production of plastic consumer goods in 1954 to 35 percent above the level of 1953. 39/ In 1954, 86 percent by value of Soviet production of plastics and plastic articles went into producer goods,* and only 14 percent into consumer goods. 40/ Eighty-five percent of the amount that went into producer goods (excluding intraministerial turnover) was allocated to heavy industry. Within heavy industry, more than one-half was allocated to the machine building, the electrotechnical, and the radiotechnical industries. 41/

The USSR apparently was unable to produce even the small amount of plastics required for consumer goods in 1954. The Ministry of the Chemical Industry was criticized for specifying a volume of production in the Plan for 1954 which would satisfy only 70 percent of the requirements of the consumer goods ministries for molding powders, thus hampering production of consumer goods. 42/

Demands for certain plastic materials in the USSR have consistently exceeded the domestic supply. Of the two major types of plastics considered in this report, polyvinyl chloride has been imported from East Germany in varying amounts since 1950.**

* It is believed that major defense needs are met from that portion allocated to producer goods.

** See V, p. 26, below.

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In spite of Soviet plans to increase production, these imports are scheduled to continue at least through 1960. 43/ The USSR has also had difficulty in meeting requirements for phenolic resin, and a shortage of this material hampered production in at least one plastics fabricating plant in 1955. 44/

III. East Germany.

A. General.

The demand for substitute materials derived from a limited number of available raw materials influenced the development of the German plastics industry during World War II. As a result, derivatives of acetylene, heavy chemicals, and coal received major emphasis. The plastics industry in East Germany has expanded significantly since World War II in spite of the dismantling and removal of some important facilities for production by the USSR. Recent research had been concentrated on the development of the newer specialized plastics with inherently superior industrial and strategic applications.

East Germany is a major producer and supplier of plastics in the Soviet Bloc. Production rose from less than 7,000 tons in 1947 to approximately 58,000 tons* in 1953. 45/ Among the plastics produced are the following: vinyls (including polyvinyl chloride, chlorinated polyvinyl chloride, and polyvinyl acetate), phenolics, aminoplasts, polystyrene, polyamides, and the cellulose (cellulose nitrate and cellulose acetate). Important plastics produced in small quantities are polyesters, silicones, and acrylics. Polyethylene and the fluorocarbons apparently are produced only on an experimental basis.

B. Vinyl Resins.

The most important plastic produced in East Germany, polyvinyl chloride, accounted for about 60 percent of total production in 1953.* 46/ Polyvinyl chloride is produced at the VEB

* This estimate does not include casein and synthetics made in experimental quantities.

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Elektrochemische Kombinat in Bitterfeld (51°37' N - 12°19' E) and at the VEB Chemische Werke Buna in Schkopau (51°24' N - 11°59' E), both under the control of the Main Administration for Heavy Chemicals of the Ministry for the Chemical Industry. 47/ Production of polyvinyl chloride has increased rapidly since World War II because of the expansion of the Schkopau plant. The facilities at Bitterfeld, which were partially dismantled by the USSR, were not replaced. The Plan for 1956-60 provides for an increase in production which will be met in part by augmenting production at Bitterfeld. 48/ This plant does not produce vinyl chloride but receives this plastic from Schkopau for use in production of polyvinyl chloride. 49/ Based on a sale price of 2,300 East German marks (DME)* per ton, the value of all polyvinyl chloride produced in 1954 was about 91,032,000 DME. 50/ Reported and planned production of polyvinyl chloride in East Germany, by plant, in 1947-60 is shown in Table 5.**

As shown in Table 5, a large expansion in production of polyvinyl chloride in East Germany is planned by 1960. Fulfillment of this plan will depend largely on an increase in production of calcium carbide to provide the required acetylene.

Chlorinated polyvinyl chloride, which is used in fibers and adhesives, is also produced in East Germany. VEB Elektrochemische Kombinat, Bitterfeld, produces chlorinated polyvinyl chloride. About 50 percent of total production is shipped to the USSR; about 30 percent goes to VEB Filmfabrik Wolfen, Bitterfeld, for production of fibers; and the remaining 20 percent is retained by the producer, largely for the manufacture of adhesives. 51/ Reported production of chlorinated polyvinyl chloride in East Germany in 1948-55 is shown in Table 6.***

Polyvinyl acetate, which is also produced at the VEB Chemische Werke Buna, Schkopau, is useful in the manufacture of adhesives and as an intermediate in production of other plastics. Production of polyvinyl acetate is small because synthetic rubber and polyvinyl chloride have been given precedence in the allocation of acetylene. In 1954, production of 489 tons of polyvinyl acetate was planned. 52/ Only 591 tons were produced in the first 9 months of 1955 compared with planned production of 1,109 tons for that period. 53/

* The official rate of exchange of 2.22 DME to US \$1.00 in 1954 is not necessarily an accurate reflection of the dollar value.

** Table 5 follows on p. 14.

*** Table 6 follows on p. 15.

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Table 5

Reported and Planned Production of Polyvinyl Chloride in East Germany
by Plant a/
1947-60

			Metric Tons
Year	VEB Elektrochemische Kombinat, Bitterfeld	VEB Chemische Werke Buna, Schkopau	Total
1947	1,728	4,602	6,330
1948	3,370	13,000	16,370
1949	4,000 <u>b/</u>	10,538 <u>c/</u>	14,538
1950	3,840	16,230	20,070
1951	5,040 <u>d/</u>	24,325 <u>e/</u>	29,365
1952	4,395	30,727 <u>f/</u>	35,122
1953	4,234	32,500 <u>g/</u>	36,734
1954	5,442	34,137 <u>h/</u>	39,579
1955	N.A.	36,000 <u>i/</u>	41,921 <u>j/</u>
1956	N.A.	41,220 <u>i/</u>	N.A.
1957	N.A.	41,220 <u>i/</u>	53,000 <u>k/</u>
1958	N.A.	N.A.	55,000 <u>k/</u>
1959	N.A.	N.A.	63,000 <u>k/</u>
1960	N.A.	N.A.	72,000 <u>k/</u>

a. 54/

b. Plan figure.

c. Estimated on the basis of production during 8 months.

d. Estimated on the basis of monthly operation.

e. Estimated from monthly average.

f. Estimated from compilation of data.

g. Estimated on the basis of production during the first 9 months.

h. Estimated from the difference between reported total production and production at Bitterfeld.

i. Plan figure. 55/

j. 56/

k. Plan figure. 57/

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Table 6

Reported Production of Chlorinated Polyvinyl Chloride
in East Germany a/
1948-55

<u>Year</u>	<u>Amount</u> <u>(Metric Tons)</u>	<u>Year</u>	<u>Amount</u> <u>(Metric Tons)</u>
1948	267	1952	999
1949	N.A.	1953	1,333
1950	524	1954	1,224
1951	564	1955	1,210

a. 58/

C. Phenolics.

Phenolics are produced at the VEB Kunstharz und Pressmassefabrik at Erkner and Espenhain and at the VEB Leuna Werke "Walter Ulbricht." The first two plants are controlled by the Main Administration for Chemical-Technical Products, and the Leuna plant is controlled by the Main Administration for Heavy Chemistry. Both Administrations are subordinate to the Ministry for the Chemical Industry. The Erkner plant produces molding powders and resins based on phenol, cresol,* and xylene.* These raw materials, which are derivatives of coal tar, are obtained from Leuna Werke and Teerdestillation- und Chemische Fabrik at Erkner. 59/ Production of phenolics in East Germany has been hampered by shortages of phenol. Estimated production of phenolics in East Germany in 1951-55 is shown in Table 7.**

* Cresol and xylene are sometimes used to replace the scarcer phenol in phenol formaldehyde resins, but the resultant plastic still is considered phenolic.

** Table 7 follows on p. 16.

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Table 7

Estimated Production of Phenolics
in East Germany a/
1951-55

<u>Year</u>	<u>Amount (Metric Tons)</u>
1951	5,900
1952	8,272
1953	10,600
1954	14,176
1955	17,100 <u>b/</u>

a. Consisting of about 50 percent resin and 50 percent filler. 60/

b. Projected on the basis of the trend in production during 1951-54.

D. Investments.

The only information available on capital investments for production of plastics in East Germany concerns facilities installed in the VEB Chemische Werke Buna and is shown in the following tabulation 61/:

<u>Purpose</u>	<u>Period of Investment</u>	<u>Amount (Million DME)</u>
Construction of vinyl acetate plant	2d quarter 1951 to 4th quarter 1954	2.0
Construction of three refrigeration units for vinyl chloride plant	3d quarter 1952 to 4th quarter 1954	0.72
Apparatus for polyvinyl chloride plant	2d quarter 1954 to 4th quarter 1954	0.08

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E. Requirements.

Domestic requirements for polyvinyl chloride in East Germany were reported to be 32,500 tons in 1954. Total production planned was 37,500 tons, with a preliminary requirement to export 10,000 tons. 62/ Actual production in 1954 was 39,579 tons, and actual exports amounted to 11,800 tons, leaving a domestic deficit of 4,700 tons. 63/

IV. Other European Satellites.

A. Albania.

Albania produces no plastic materials and fabricates no plastic articles.

B. Bulgaria.

Bulgaria is experimenting with production of plastic materials, but as far as can be determined, there is no commercial production. Plastic articles are fabricated from imported raw materials on a small scale. Future development of the industry probably will depend on the growth of a market for products which can be made from indigenous raw materials. Because the potential supply of raw materials and the market for finished products are both small, it is doubtful whether plastics will be made in Bulgaria in significant quantities in the near future.

C. Czechoslovakia.

1. General.

The manufacture of plastic materials in Czechoslovakia has lagged behind the growth of the well-established plastics fabricating industry. The consumption of plastics per capita is high, however, amounting to 1.6 kilograms (kg) in 1951. 64/ Consumption rose approximately 300 percent between 1946 and 1952, phenolics accounting for about 35 percent and vinyl plastics for 25 percent of consumption in 1952. 65/

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2. Production.

Production of plastics in Czechoslovakia was scheduled to increase from 7,325 tons, valued at 417,615,000 old crowns,* in 1948 to 40,480 tons, valued at 1.2 billion old crowns, in 1954. 66/ There are indications that the goal was not attained and that about 16,300 tons were produced in 1953.** 67/ Estimated production in the years 1947-53 is as follows:

<u>Year</u>	<u>Production (Metric Tons)</u>
1947	6,220***
1948	7,325
1949	9,120****
1950	10,915****
1951	12,710****
1952	14,505****
1953	16,300

Czechoslovakia produced 3,000 tons of polyvinyl chloride in 1955 and plans to produce 9,000 tons in 1960. 69/

3. Vinyl Resins.

Polyvinyl chloride is produced at the "Wilhelm Pieck" Chemical Plant, Novaky (48°43' N - 18°33' E). 70/ The raw materials, chlorine and carbide, are produced at the plant. 71/ A large-scale addition to the plastics section of this plant was under construction in 1956. 72/ At the end of 1953, production of polyvinyl chloride in Czechoslovakia was hampered by the lack of suitable softeners. 73/

* The official rate of exchange of 50 Czechoslovak crowns to US \$1.00 before the currency revaluation of 1953 is not necessarily an accurate reflection of the dollar value. All value figures for Czechoslovakia are given in terms of the old crown.

** It was reported that production had risen 122 percent in the period 1949-53.

*** 68/

**** Estimated on the basis of production in 1948 and 1953.

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4. Phenolics.

Phenolics are the major plastics produced in large amounts in Czechoslovakia. They are produced at the Uma Plastics Materials Plant in Semtin, near Pardubice (49°55' N - 16°00' E) 74/; at the Association for Chemical and Metallurgical Production, Usti nad Labem (50°40' N - 14°02' E) 75/; at the Stalin Works, Most (50°32' N - 13°39' E) 76/; and at the Gumon National Enterprise, Bratislava (48°09' N - 17°07' E). 77/

The greatest obstacle to the development of production of phenolics in Czechoslovakia has been the lack of phenol. In 1952-53 the shortage of phenol resulted in an attempt to produce phenolics with a lower resin content, but the resultant product proved unsatisfactory for industrial use because of poorer mechanical properties. 78/ The importance of the plastics industry as a consumer of phenol in Czechoslovakia in 1953 is shown in the following tabulation 79/:

<u>Use</u>	<u>Percent of Total</u>
Production of pressed substances (plastics)	38.0
Production of synthetic fibers	35.0
Production of varnishes, cements, and anticorrosion materials	5.5
Other consumption	21.5
Total	<u>100.0</u>

5. Investments.

Planned investment in the plastics industry of Czechoslovakia during 1949-53 was 377,067,000 old crowns. 80/ By 1954, this amount was expected to yield an increase in production of plastics compared with 1948 of 33,155 tons, valued at 782,385,000 old crowns. 81/ Raw materials and labor for the increased production were expected to cost 528 million old crowns annually, resulting in a net annual increment in value of 254,385,000 old crowns, or 68 percent of the planned investment. 82/

6. Distribution and Use of Product.

More plastic articles are available to the consumer in Czechoslovakia than in other countries in the Soviet Bloc. Not only

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is there a high consumption of plastics per capita but a greater proportion of production of plastics goes into consumer goods. Apparently there has been some dissatisfaction in the Ministry of the Chemical Industry with the small utilization of polyvinyl chloride by heavy industry compared with its use in consumer goods. The reasons given for inadequate utilization include the laxity of ministries in requiring the use of polyvinyl chloride, the lack of confidence in the new material because of limited experience, and the high cost of the plastic compared with metals in 1953. ^{83/} The reported distribution of polyvinyl chloride in 1952-54 is shown in Table 8.

Table 8

Distribution of Polyvinyl Chloride in Czechoslovakia ^{a/}
1952-54

Use	Percent of Total		
	1952	1953 ^{b/}	1954 ^{b/}
Heavy industry	49.0	34.3	27.4
Light industry	10.2	12.1	9.3
Artificial leather	11.2	15.5	19.5
Other consumer goods	29.6	38.1	43.8
Total	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>

a. ^{84/}

b. Presumably planned.

The estimated use of phenolic pressed products in Czechoslovakia in 1953 is as follows ^{85/}:

Use	Percent of Total
Technical pressed products	53.0
Pressed products for electrical industry	23.0
Pressed consumer goods	24.0
Total	<u>100.0</u>

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D. Hungary.

1. General.

Hungary has a small plastics materials industry confined largely to production of phenolic and amino resins and molding powders. The goal of production of plastics materials for 1960 is 11,600 tons, ^{86/} 6,000 tons of which will be polyvinyl chloride. ^{87/} Production in 1955 amounted to 2,700 tons of plastics materials. ^{88/} The consumption of plastics in 1960 is planned to be 2 kg per capita, compared with consumption of 0.66 kg per capita in 1955. ^{89/}

2. Vinyl Resins.

The first Hungarian polyvinyl chloride was produced in the experimental plant of the Research Institute for Organic Chemistry in Budapest, probably in 1955. ^{90/} Construction of an experimental plant with an annual capacity of 300 tons ^{91/} was begun in January 1956 at the Hungaria Chemical Works in Budapest, and production is scheduled to begin in August 1957. ^{92/} A plant to produce 10,000 tons of polyvinyl chloride annually has been planned as part of the Tisza Region Chemical Combine, Tiszapalkonya (47°56' N - 21°05' E). ^{93/} This plant is expected to begin operations by the end of the Second Five Year Plan (1956-60) and at that time to meet all domestic needs for polyvinyl chloride. ^{94/} The process will utilize natural gas (methane) piped in from Rumania. ^{95/} East Germany is to supply equipment for the new Hungarian plant, but the equipment necessary to process the natural gas is to be purchased from the West. ^{96/}

3. Phenolics.

Phenolics are produced at the Kobanya Synthetic Materials Plant and at the Cable and Synthetic Materials Plant, both located in Budapest. ^{97/} Production of phenolics has been hampered by the lack of raw materials. In 1954, for example, production of phenol and cresol used in production of phenolic press powders satisfied only 20 to 25 percent of the national demand. ^{98/}

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E. Poland.

1. General.

The plastics industry in Poland was almost nonexistent before 1939. Plastic articles had to be imported because only small amounts of phenolics were produced. Production of plastics declined to an even lower level during the German occupation, but in 1945 the industry was revived. By 1953, plastics comprised 6.1 percent* of total Polish production of chemicals, and the plastics industry employed 4.2 percent** of the total labor force in the chemical industry. 99/ Nevertheless, although Poland ranked 5th in Europe in industrial production in 1953, it ranked only 12th in production of plastics and 13th in the consumption of plastics. 100/ Production is expected to be about 1.8 kg per capita in 1960. 101/

2. Production.

Estimated total production of plastics in Poland in 1955 was 15,800 tons.*** 102/ Planned production in 1960 is estimated at 52,500 tons, including 18,000 tons of polyvinyl chloride and 31,500 tons of phenolics and amino resins.*** 103/ Estimated production of plastics in Poland in 1949 and 1952-60 is shown in Table 9.****

The larger materials and processing plants in Poland are subordinate to the Central Administration of the Rubber and Plastics Industry of the Ministry of Chemical Industries, whereas the smaller enterprises, engaged principally in processing, are subordinate to the Ministry of Minor Industries and Workshops. 104/

3. Vinyl Resins.

A pilot plant for production of polyvinyl chloride began operations about 1949 at the chemical works at Dwory near Oswiecim. 105/ Large-scale production was scheduled to begin in 1956, 106/ but expansion of the plant was still under way in the middle of the year. 107/

* Includes raw materials.

** Includes those persons employed in fabricating plants.

*** For methodology, see Appendix B.

**** Table 9 follows on p. 23.

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Table 9

Estimated Production of Plastics in Poland a/
1949 and 1952-60

			Metric Tons
<u>Year</u>	<u>Phenolics</u>	<u>Polyvinyl Chloride</u>	<u>Total</u>
1949	2,200 <u>b/</u>	N.A.	2,500 <u>c/</u>
1952	4,000 <u>b/</u>	N.A.	4,700 <u>c/</u>
1953	7,000 <u>c/</u>	N.A.	8,000 <u>c/</u>
1954	9,000 <u>c/</u>	N.A.	11,000 <u>c/</u> <u>d/</u>
1955	12,000 <u>c/</u>	1,000 <u>e/</u>	15,800 <u>f/</u>
1956	N.A.	N.A.	N.A.
1957	N.A.	4,000 <u>g/</u>	N.A.
1958	N.A.	7,000 <u>g/</u>	N.A.
1959	N.A.	11,000 <u>g/</u>	N.A.
1960	25,000 <u>h/</u>	18,000	52,500 <u>i/</u>

a. Totals include other plastics in addition to phenolics and polyvinyl chloride. For methodology, see Appendix B.

b. Estimated on the basis of the ratio between production of phenolics and total production of plastics in 1953.

c. 108/

d. Estimated on the basis of anticipated production of 400 grams per capita.

e. Estimated as 1,000 tons or less.

f. 109/

g. Plan figure. 110/

h. Planned production of phenolics and amino resins in 1960 is estimated at 31,500 tons. It is believed that phenolics will constitute the bulk of this production. 111/

i. 112/

Plans for the works include a plant to produce chlorinated polyvinyl chloride. 113/ Raw materials for the vinyl products will come from the carbide and chlorine facilities of the works. 114/ After 1960, annual production of 30,000 tons of vinyl resins is anticipated. 115/ This

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amount is expected to yield about 45,000 tons of resin products in the form of plastics, varnishes, glues, and other materials. 116/

4. Phenolics.

The main producer of phenolics in Poland is the Synthetic Products Plant at Pustkow, which is largely responsible for the increase in production of phenolics between 1949 and 1953. 117/ Two other possible producers are the Paint and Lacquer Plants No. 1 and No. 2 at Gdansk. 118/ A large portion of production at Pustkow goes to the electrotechnical industry. 119/ The achievement of planned increases in production of bakelite through 1960 will depend largely on the availability of phenol from coking plants because the more expensive synthetic phenol probably will go into the synthetic fiber industry. 120/

5. Costs of Production.

The costs of production of plastics* in Poland in 1953 are shown in Table 10. Costs of direct materials in the plastics industry are higher than those in the chemical industry as a whole because of the large volume and low cost of many of the raw materials used in the chemical industry.

Table 10

Costs of Production of Plastics in Poland a/
1953

Industrial Sector	Direct Materials	Direct Labor	Departmental Costs	All Plant Costs	Percent
					Miscellaneous Costs
Plastics industry	66.6	7.4	13.2	9.6	3.2
Total chemical industry	51.0	6.3	23.1	7.2	12.4

a. 121/

* Presumably applies to the plastics industry as a whole.

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6. Investments.

According to an article written in 1956 on the efficiency of investments in the Polish chemical industry, the capital coefficient for the plastics industry is approximately 0.27 122/: that is, an investment of 0.27 zloty* will result in a product with an annual sales value of 1 zloty.** Capital coefficients for various branches of the Polish chemical industry in 1956 are shown in Table 11.

Table 11

Capital Coefficients for Various Branches of the
Chemical Industry in Poland a/
1956

<u>Branch of Industry</u>	<u>Index</u>
Plastics	0.27
Chemical synthesis	2.62
Artificial fibers	1.18
Inorganic chemicals	2.06
Organic chemicals	1.49
Sulfur and phosphorus fertilizers	1.92
Rubber industry	0.65
Paint and varnish	0.25
Technical gases	2.16
Mining materials	1.79

a. 123/

* The official rate of exchange is 4 zlotys to US \$1.00.

** It should be noted that the capital coefficient, in expressing the relationship between capital investment and sales value, is not net of other inputs and by itself does not indicate the profitability of capital investment. Plastics may have much higher costs for raw materials and labor per dollar of sales than the chemical synthesis branch of the chemical industry.

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F. Rumania.

1. General.

Rumania produces almost no plastic materials. During the Second Five Year Plan (1956-60), however, Rumania plans to increase production of plastics to 16,000 tons, 124/ including 10,500 tons of polyvinyl chloride. 125/

2. Vinyl Resins.

Vinilin, a polyvinyl chloride resin, was reportedly produced in Rumania at the end of 1954 on an experimental basis, 126/ possibly at the Bela Breiner Plastic Plant in Timisoara (44°47' N - 21°13' E). 127/ Production of only 700 tons of polyvinyl chloride is planned for 1958. 128/ Plans call for development of an acetylene chemical products industry based on Rumanian natural gas. A plant with an annual capacity of 10,000 tons of polyvinyl chloride and a plant for production of polyvinyl acetate are planned. 129/ Preparations for industrial production of polyvinyl chloride were being made in March 1956 at Chemical Combine No. 2 in Tirnaveni (46°20' N - 24°16' E). 130/ The acetylene and chlorine required will be produced at the combine. 131/

3. Phenolics.

Production of phenolics in Rumania has been identified at Chemical Combine No. 1 in Fagaras (45°51' N - 24°59' E). * 132/ A new plant for production of phenolics for electrical equipment and for consumer goods is under construction in Medias (46°10' N - 24°21' E), 133/ and the raw materials for this plant are to be supplied by domestic chemical plants. This new plant was scheduled to go into operation in the second half of 1956. 134/

V. Trade.

The trade of the Soviet Bloc in the plastics considered in this report has been confined principally to exports of polyvinyl chloride from East Germany. Data on such shipments generally are derived from formal trade agreements, and the figures should be considered minimal

* Production of phenolics may not be limited to this plant.

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because East Germany exports an unknown quantity of plastics to other countries of the Bloc through covert arrangements. Available data on East German exports of polyvinyl chloride are shown in Table 12.

Table 12

Exports of Polyvinyl Chloride from East Germany
1950-56 and 1960

<u>Year</u>	<u>Metric Tons</u>	
	<u>To the USSR</u>	<u>Total</u>
1950	1,933 <u>a/</u>	6,000 <u>b/</u>
1951	5,065 <u>c/</u>	8,619 <u>d/</u>
1952	6,850 <u>e/</u>	10,754 <u>f/</u>
1953	N.A.	11,300 <u>g/</u>
1954	6,057 <u>h/</u>	12,000 <u>i/</u>
1955	N.A.	11,800 <u>j/</u>
1956	N.A.	12,000 <u>k/</u>
1960	7,000 <u>l/</u>	20,000 <u>m/</u>

a. Estimated on the basis of shipments during 9 months. 135/

b. 136/

c. 137/

d. 138/

e. 139/

f. 140/

g. Estimated on the basis of shipments during 9 months. 141/

h. Estimated on the basis of shipments during 4 months. 142/

i. Plan figure. 143/

j. Includes 4,100 tons reportedly shipped to capitalist countries. 144/

k. Plan figure. 145/

l. Plan figure. 146/

m. Plan figure. 147/

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Estimated average unit prices of all known exports of polyvinyl chloride from East Germany in 1951-55 are shown in Table 13.

Table 13

Estimated Average Unit Prices of Exports of Polyvinyl Chloride
from East Germany
1951-55

Rubles per Metric Ton			
Year	To the USSR	To Other Bloc Countries	All Exports <u>a/</u>
1951 <u>b/</u>	1,780	2,116	1,914
1952 <u>c/</u>	1,980	2,115	2,049
1953 <u>d/</u>	1,833	2,222	1,914
1954 <u>e/</u>	N.A.	N.A.	1,834
1955 <u>e/</u>	N.A.	N.A.	1,873

- a. Includes exports to Free World, not shown in the table.
- b. Estimated from data in source 148/.
- c. Estimated from data in source 149/.
- d. Estimated from Plan. 150/
- e. Plan figure. 151/

The USSR receives preferential treatment, with respect to both the quantity shipped and the price. The same type of treatment has been reported for other products of the chemical industry.

Planned exports of polyvinyl chloride from East Germany to the Soviet Bloc in 1957-60 are shown in Table 14.*

A comparison of the total exports planned from East Germany in 1960 with those planned to go to the Soviet Bloc shows that East Germany intends to sell increased amounts to non-Bloc countries. Shipments to non-Bloc countries in the past have often been at prices considerably below US prices. In 1952, East German polyvinyl chloride

* Table 14 follows on p. 29.

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Table 14

Planned Exports of Polyvinyl Chloride from
East Germany to the Soviet Bloc a/
1957-60

Thousand Metric Tons				
<u>Destination</u>	<u>1957</u>	<u>1958</u>	<u>1959</u>	<u>1960</u>
USSR	7.0	7.0	7.0	7.0
Czechoslovakia	2.0	2.1	2.2	2.1
Poland	1.0	1.0	1.0	2.0
Hungary	0.8	1.0	1.0	0
Rumania	0.05	0	0	0

a. 152/

was offered to West Germany for \$0.17 per pound 153/ and in 1953, to Mexico for \$0.195 per pound. 154/ The price for US-produced polyvinyl chloride in 1952 and 1953 was \$0.38 to \$0.39 per pound. 155/ Some of the East German shipments of polyvinyl chloride to the West have not been for competitive reasons or to disrupt Western markets but to obtain needed equipment or materials. Typical of such barter transactions was an agreement concluded in 1954 with a Swiss firm which called for the exchange of 220 tons of East German polyvinyl chloride for West German heat exchangers valued at US \$110,000. 156/

The West has supplied some polyvinyl chloride to the Soviet Bloc, particularly to Poland. 157/ Polyvinyl acetate has been supplied by the West to Poland, Czechoslovakia, and East Germany, 158/ and polyvinyl butyral (used for safety glass) has been shipped to Poland, Czechoslovakia, and Bulgaria. 159/

Trade in phenolics does not appear to be extensive in the Soviet Bloc, although some phenolic resins and fabricated articles are exported by East Germany, Poland, and Czechoslovakia. 160/

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VI. Inputs of Raw Materials.

The most important raw materials used in production of the plastics considered in this report are phenol and formaldehyde for the phenolics and calcium carbide and hydrochloric acid for polyvinyl chloride. Available data on inputs of raw materials for selected plastics in the Soviet Bloc are shown in Table 15.*

VII. Capabilities, Vulnerabilities, and Intentions.

Imports of phenolics and polyvinyl chloride by the Soviet Bloc from the West are small compared with domestic production and are confined to the European Satellites except East Germany. The Bloc appears to produce sufficient polyvinyl chloride and phenolics to meet its most urgent industrial and military needs but an insufficient quantity to meet consumer or extensive industrial demands. Plans to increase production are dependent on the availability of increased quantities of raw materials.

Phenolic and vinyl resins are produced in the Soviet Bloc in only a few plants. In the USSR and East Germany, only four plants produce polyvinyl chloride. In East Germany the vinyl chloride required for polyvinyl chloride is produced only at VEB Chemische Werke Buna, Schkopau, and is directly dependent on carbide and chlorine produced at the same plant.

Phenol has been in short supply in the Bloc. Despite attempts to increase production of phenol, Bulgaria, Czechoslovakia, and Hungary import phenol from the West 161/; and Bulgaria, Czechoslovakia, and Rumania still will be partially dependent on imports from other Bloc countries in 1960. 162/ To some extent, Hungary and the USSR will remain dependent on imports of carbide from other Bloc countries through 1960. 163/

Another factor that may hinder plans of the Soviet Bloc to increase production of plastics is the shortage of processing equipment. The raw plastic materials are useless without the means to convert them into finished articles. Recent visits of delegations from the Bloc to

* Table 15 follows on p. 31.

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Table 15
Estimated Inputs of Raw Materials for Selected Plastics in the Soviet Bloc
1955

Plastic	Raw Material	Country	Production of Plastic	Metric Tons	
				Input of Raw Material Per Ton of Production ^{a/}	Total
Phenolics	Phenol ^{b/}	USSR	19,350 c/	0.84	16,254
		East Germany	8,550 c/	0.84	7,182
		Poland	6,000 c/	0.84	5,040
Phenolics	Formaldehyde	USSR	19,350 c/	0.54	10,449
		East Germany	8,550 c/	0.54	4,617
		Poland	6,000 c/	0.54	3,240
Polyvinyl chloride	Calcium carbide	East Germany	42,000	1.35	56,700
		Czechoslovakia	3,000	1.35	4,050
Polyvinyl chloride	Hydrochloric Acid	East Germany	42,000	0.70	29,400
		Czechoslovakia	3,000	0.70	2,100

a. ^{164/}

b. The figures for phenol are assumed to include cresol and xyleneol, of which an undetermined quantity goes into phenolic plastics.

c. In terms of resin, which is about 50 percent by weight of phenolic plastics.

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Western nations clearly show that the Bloc is dependent on the West for some types of equipment as well as for technology. 165/

The most versatile plastic available in moderate volume in the Soviet Bloc is polyvinyl chloride. Bloc plans call for sizable increases in production of polyvinyl chloride by 1960. 166/ Production of phenolic resins probably will increase at a slower rate than that of polyvinyl chloride.

It is unlikely that the military intentions of the Soviet Bloc can be gauged by developmental plans for production of polyvinyl chloride or phenolics, because these plastics may be used for a variety of consumer and industrial as well as military applications. Production of other plastics not considered in this report, such as the fluorocarbons or silicones, may indicate emphasis in the Soviet Bloc on jet aircraft, missiles, or nuclear energy.

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APPENDIX A

TECHNOLOGY

Although a method for preparing cellulose nitrate was discovered by a French chemist in 1833, commercial exploitation of this research did not occur until 1868, when an American inventor produced the first commercial plastic of the material and called it "celluloid." The next major development in the industry was the introduction in 1909 of phenol-formaldehyde plastic, named bakelite for its inventor, Dr. Baekeland. In both cases the basic research had been done by European chemists years before the material came on the market, but the practical application depended upon further chemical study to produce a usable product.

The physical limitations of these two materials led to the gradual development of other plastics, each having properties which made it superior for certain applications. After 1926 the tempo of development increased, as is evident from the following list which shows the year each plastic was introduced commercially:

<u>Date</u>	<u>Materials</u>	<u>Typical Application</u>
1868	Cellulose nitrate (celluloid)	Eye glass frames
1909	Phenol-formaldehyde (bakelite)	Telephone hand sets
1919	Casein	Knitting needles
1926	Alkyds (glyptals)	Lacquers, enamels
1927	Cellulose acetate	Toothbrushes, packaging
1929	Amino-plasts (urea formaldehyde)	Lighting fixtures
1931	Acrylics (lucite)	Aircraft enclosures
1936	Polyvinyl chloride (geon)	Rainwear, pipe
1938	Polystyrene	Kitchenware
1938	Polyamides (nylon)	Gears, fibers
1942	Polyethylene	Squeezable bottles
1942	Polyesters	Partitions
1943	Silicones	Motor insulation
1943	Fluorocarbons	Industrial gaskets

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Many materials of high molecular weight occur in nature. One is rubber, distinguished by its ability to return quickly to its original dimensions after being deformed by relatively low pressure. Because of this property, rubber is known as an elastomer. Natural high-polymers include rosin, amber, gutta percha, balata, and chicle, all of which are chemically allied to plastics but are beyond the scope of this report.

Plastics are compounds having high molecular weights. They are made chemically by combining molecules, the smallest chemical units by which a substance can be identified, to form macromolecules, or high-polymer compounds. The process might well be compared to building a structure with bricks as a building material. The individual bricks would represent molecules, and the completed structure would be the macromolecule, or high-polymer product. In making plastics the combination, or chemical reaction, can usually be accelerated by the application of heat and pressure, and the characteristics of the end product may be modified or controlled by using other chemicals or by altering the physical conditions under which the reaction takes place. As in all chemical reactions, the final product obtained depends upon the raw materials used.

Plastics can be classified in two general groups: thermosetting resins and thermoplastic resins. Thermosetting resins can be molded into a final shape with the aid of heat and pressure but cannot be reshaped once they have assumed this form. Thermoplastic resins, on the other hand, can be reshaped repeatedly by the application of heat and pressure. Further identification of plastics is based on the raw materials from which they are made. There are 14 major types, each of which designates several related or similar products, so that the total number of plastics is quite large and continues to grow as modifications and combinations of existing types are developed. The major types of plastics, divided into two general groups, with trade names, raw materials, characteristics, and principal applications, are shown in Table 16.*

Manufacturing methods in the plastics industry are nearly uniform throughout the world, particularly for the well-established types which form the bulk of production of plastics in the Bloc. On the other hand, some of the newer types of plastics are based on complicated chemical reactions and manufacturing processes which are closely guarded trade secrets, and production of these materials depends upon the successful solution of many technical problems. As of October 1956 the Soviet Bloc had been only partially successful in solving these problems, and its**

* Table 16 follows on p. 35.

** Continued on p. 39.

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Table 16
Major Types of Plastics

Chemical Name	Trade Name or Designation	Raw Materials	Characteristics	Applications
<u>Thermoplastic resins</u>				
Cellulosics Acetate	Tenite (US) Tsellon (USSR)	Cellulose (wood) Acetic acid (wood or petroleum)	Mechanical strength, toughness, transparency, light weight, optical clarity	Electrical insulation, molded consumer goods, films for packaging
	Nitrate	Cellulose (wood) Nitric acid Coal, air Natural gas	Toughness, ease of fabrication, resiliency, low water absorption, high flammability	Coatings for leather and fabrics, lacquers, consumer items
Vinyls Acetate	PVA (US) Vinalit (East Germany) Polivinilatsetat (USSR)	Acetylene (coal, limestone) Acetic acid (wood or petroleum)	Colorless, odorless, soluble in aromatic solvents, resistant to water and alkali	Coatings for synthetic leather, paint base, adhesives, electrical tape
	Chloride	Acetylene (coal, limestone) Chlorine (salt)	Self-extinguishing, colorless, odorless, strong, durable, may be plasticized to flexible film	Sheeting for consumer items such as curtains, soles and heels, elec- tric wire insulation, molded pipe for water and oil, industrial coating
Butyral	"Saflex" (US) Butvar (USSR)	Butanol Acetylene (coal, limestone) Acetic acid (wood or petroleum)	Colorless, resistant to sunlight	Artificial leather, interlayer for safety glass

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Table 16

Major Types of Plastics
(Continued)

Chemical Name	Trade Name or Designation	Raw Materials	Characteristics	Applications
Thermoplastic resins (Continued)				
Polystyrene	Styron (US) Trolitul (East Germany) Polistiroil (USSR)	Benzol (coal tar) Ethylene (petroleum)	Superior dielectric properties, ease of molding, high gloss, crystal clarity, shock resistance, soluble in aromatic hydrocarbons, becomes soft at 220° to 250° F	Foamed resins, extruded pipe, molded articles, leather finishing
Polyamids	Nylon (US) Perlon (East Germany) Kapron (USSR) Terelin (USSR)	Salt Coal tar Water Air	High strength, low coefficient of friction, resistance to solvents, slow burning and self-extinguishing, low specific gravity	Fibres and filaments, bristles, molded gears and machine parts, bearings
Acrylic	Plexiglas (US) Lucite (US) Piacryl (East Germany) Orgsteklo (USSR)	Petroleum Coal tar	Crystal clarity, colorless, light conductive	Consumer items, sheeting, signs, aircraft cowlings and bubbles
Polyethylene	Alathon (US) Polythene (East Germany) Polithene (USSR)	Petroleum Natural or coal gas	High electrical resistance, low specific gravity, flexibility over a wide temperature range, chemically stable	Packaging, films, wire insulation, squeeze bottles, molded goods, containers for acids, battery cases
Fluorocarbons	Kel-F (US) Teflon (US, East Germany, USSR) Ariivos (USSR)	Fluorspar Chlorine (salt) Methyl alcohol (wood)	Extremely tough, chemically inert, withstands extremely high temperatures	Acid-proof pipe and fittings, impregnated fibers, molded parts, tank linings

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Table 16

Major Types of Plastics
(Continued)

Chemical Name	Trade Name or Designation	Raw Materials	Characteristics	Applications
<u>Thermosetting resins</u>				
Phenol Formaldehyde	Bakelite (US) Plastadur (East Germany) Karbolit (USSR) Phenoplast (USSR)	Phenol (coal tar) Formaldehyde (methyl alcohol)	Hard, brittle, opaque, dark colored, good dielectric properties, good heat resistance to 300°F, low cost	Radio and television cabinets, electrical parts, utensil handles
Casein	Ameroid (US) Gallalith (East Germany) Galalit (USSR)	Casein (skimmed milk) Formaldehyde (methyl alcohol)	Hard, rigid, resists flexing, withstands ordinary solvents, is adversely affected by humidity and temperature changes	Buttons, buckles, novelties
Aminoplasts	Beetle (US) Melmac (US) Piatherm (East Germany) Melaminhartz (East Germany) Karbamidnayasmola (USSR)	Urea or melamine (coal, limestone, and air) Formaldehyde (methyl alcohol)	High arc resistance, nontoxic, translucent, good heat resistance, relatively expensive	Plywood adhesives, tableware, paper coatings, distributor heads, textile coatings, molded products
Polyesters	Laminac (US) Polyphir (East Germany) Poliefir (USSR)	Polybasic acids (petroleum) Styrene (coal tar)	Light color, good resistance to weathering, cures with little or no pressure	Laminating adhesives, structures (when reinforced with glass), adhesive for wallboard
Alkyds	Plaskon (US) Glyptal (US) Glyptal (USSR)	Phthalic anhydride (coal tar or petroleum) Glycerol (petroleum or fatty oils)	High gloss, good electrical insulators, good resistance to weathering	Insulating varnish, wood and metal finishes

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Table 16

Major Types of Plastics
(Continued)

Chemical Name	Trade Name or Designation	Raw Materials	Characteristics	Applications
<u>Thermosetting resins</u> (Continued)				
Epoxy	Araldite (US) Araldit (East Germany)	Petroleum Coal tar	Unaffected by acids, solvents, and alkalis; high tensile strength; good dielectric properties	Protective coating of tanks, adhesives, paints, tools, adhesive for bonding metal to metal and metal to wood
Silicones	Silicone (US) Silikon (East Germany, USSR)	Sand, salt, petroleum	High heat resistance, great water repellance, good lubricating properties, high cost	Electrical insulation, gaskets, greases, coatings, laminates, high-temperature molding compounds, polishing agents, jet engine parts, foamed resins

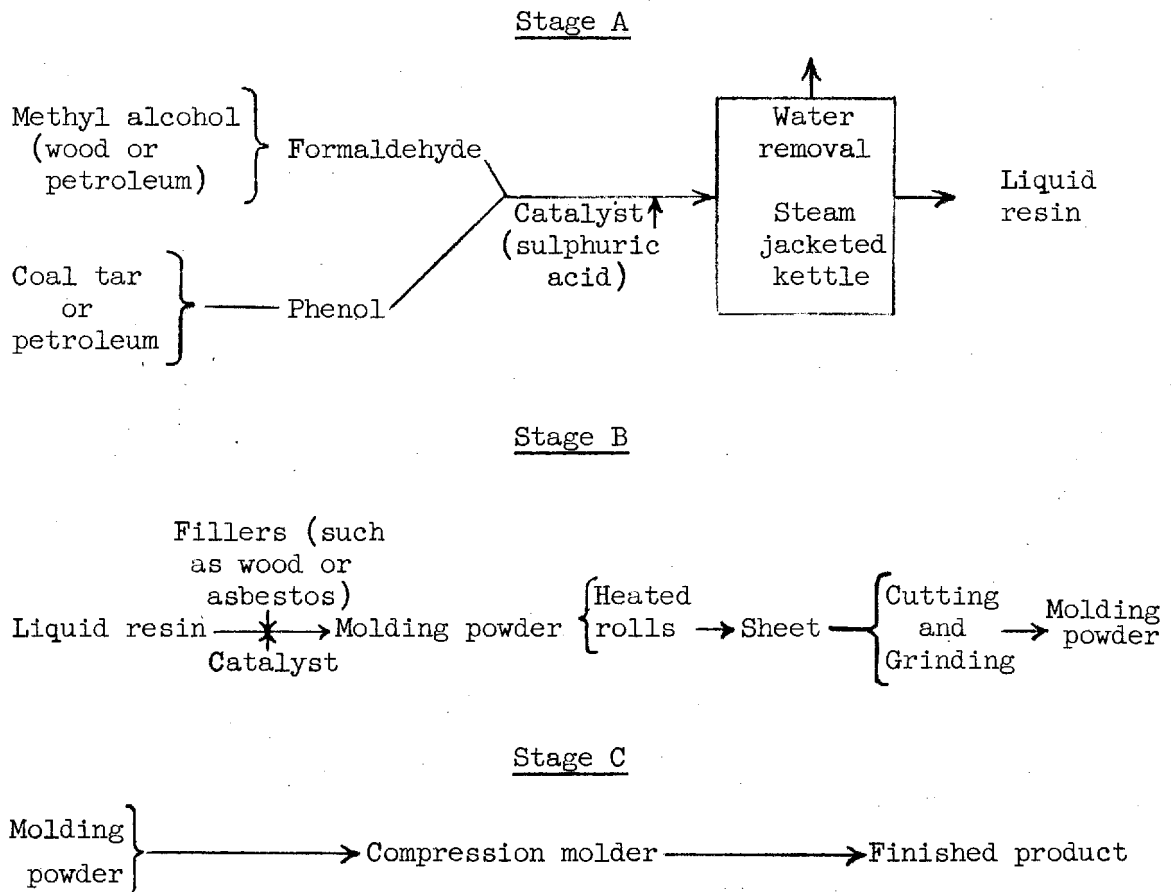
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production is confined to laboratory or pilot plant operations. For this reason, only the processes used to make the types of plastics known to be produced in volume in the Bloc are described in this report.

Plastics of the phenol-formaldehyde type were first made commercially in the US in 1907. Production was started in the USSR in about 1915 at the Karbolit Plant at Orekhovo-Zuyevo. The following steps are involved in the process:



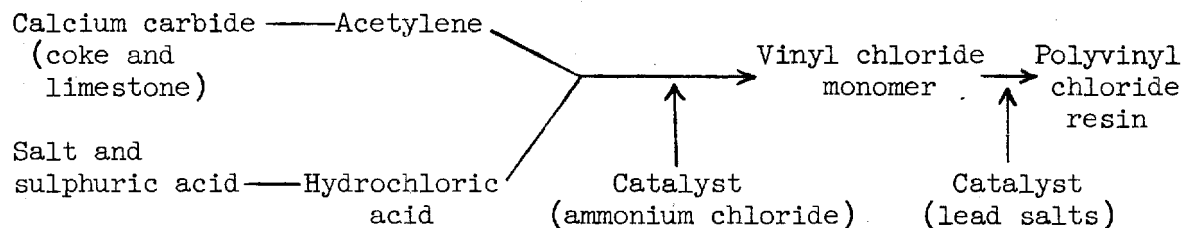
The plastic at stage B is not completely polymerized, the final action taking place in the compression molder which operates at 300° to 350° F. As can be seen from the above diagrams, phenolics are made from raw materials which are plentiful, and the process is relatively simple.

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The product is widely used for making electrical fittings and many consumer items such as utensil handles, telephone parts, and radio cabinets. Phenolics are useful up to 300° F and have a high resistance to moisture as well as good insulating properties. On the other hand, phenolics are brittle and are dark in color, hence cannot be used for products subject to shock or for light-colored objects.

Although vinyl resins are produced by a chemical reaction which was discovered in 1838, the first commercial product was not offered in the US until 1928. Polyvinyl chloride, acetate, and butyral were brought into production by various manufacturers in the US and Canada, and a modification known as vinylidene chloride, which is particularly useful for extrusions, was brought into production in 1939. Polyvinyl chloride was made in Germany in 1912 at Bitterfeld but was not made in the USSR in volume until after 1947. The vinyl resins have a common base in that they are formed by combining elements or groups of elements with acetylene gas. The simplest member of the group from the point of view of manufacture is polyvinyl chloride, which is made by the following steps:



As has been previously noted, polyvinyl chloride is a thermoplastic and is usually compounded with various other chemicals to produce a material which can be processed into molded articles, rolled into sheets, or extruded either as electrical insulation on wire or as flexible tubing. As a group, vinyl chloride resins have the widest versatility of any of the plastics. New products and applications are constantly being developed, and vinyl chloride resins account for about 14 percent of all consumption of synthetic resins in the US. A recent development in which the USSR is particularly interested is the fabrication and use of plastic pipe to replace steel and other metals. Plastic pipe can be used for carrying oil, gas, water, and chemical solutions; is light in weight compared to metal; is easily installed; resists corrosion; and costs less to install than metal pipe. The Communists are particularly interested in the saving of metals to be realized by using plastic pipe in their oilfields and chemical plants.

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APPENDIX B

METHODOLOGY

1. Production.

Estimates of production in this report were derived from data on plants, published figures on Plans and fulfillment of Plans, reported percentage increases in production, and data on production per capita. Estimates for years for which no data on production were available were obtained by extension or interpolation, on the basis of available estimates for other years.

Estimates on production in East Germany were based on reports on plants, Plans, and data on fulfillment of Plans. Estimates for other European Satellites, except Poland, were derived from published Plans and data on fulfillment of Plans.

The methodology for deriving the estimates of total production of plastics in the USSR in 1950-55 and 1960 was as follows:

One source gave production of phenol formaldehyde in 1932 as 856 tons. ^{167/} Production of phenol formaldehyde plastics was said to have increased 8 times between 1932 and 1937, giving a figure of 6,848 tons for 1937. ^{168/} The Plan for 1941 called for production of 13,500 tons of all plastics, including 9,400 tons of phenol formaldehyde plastics. ^{169/} Estimated production of phenol formaldehyde in 1940, 8,750 tons, was derived by interpolation. By using the same ratio between production of phenol formaldehyde and production of all plastics that existed in the Plan for 1941, production of all plastics in 1940 is estimated to have been 12,500 tons.

The Plan for 1950 called for production of phenolics to be 2.25 times that of 1940 and for production of other plastics to be about 4 times that of 1940. ^{170/} On the basis of estimated production in 1940, an estimate of total production of 34,700 tons, including 19,700 tons of phenol formaldehyde, was derived.

Production of plastics in 1951-52 was estimated by interpolating between figures for 1950 and 1953.

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Gross production of plastics in 1953 was reported to be 190 percent of that in 1950. 171/

Production of plastics in 1954 was estimated by interpolating between figures for 1953 and 1955.

Production of plastics, lacquers, and paints in 1955 was reported to be 2.41 times that of 1950. 172/ In the absence of further evidence, production of plastics in 1955 is assumed to be 2.41 times that of 1950.

It has been reported that production of plastic materials and synthetic resin in 1960 is to be more than 2.5 times that of 1955. 173/

The methodology for deriving estimates of production of phenol formaldehyde in 1953-55 was as follows:

It was reported that production of phenol formaldehyde molding powders in 1953 was 1.5 times that of 1950. 174/ Because almost the entire production of phenol formaldehyde is in the form of molding powders, the 1.5 ratio was used to estimate total production. Production in 1954-55 was estimated by projecting the figures for 1950-53.

The estimates of production of polyvinyl chloride in 1949 were derived from railroad car loadings. One source reported that 20 tons of polyvinyl chloride were loaded per day, 175/ and a second source reported that one railroad car was loaded per day. 176/ On the basis of 300 days of operation, the estimate of 15 to 20 tons of polyvinyl chloride loaded per day gives 4,500 to 6,000 tons for the year.

The methodology for deriving estimates of total production of plastics in Poland in selected years, 1949-60, was as follows:

Polish production of plastics in 1949 was reported to be about 100 grams per capita. 177/ The population in 1949 was about 25 million. 178/ Therefore, production of plastics in 1949 was about 2,500 tons. The division between phenolic and other plastics was estimated.

Production planned for 1953 was stated to be 143.5 percent of that in 1952. 179/ The original plan for production in 1953 was 6,666 tons, and production planned for 1952 must have been 4,700 tons.

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Production of 8,000 tons was reported for 1953. 180/ Other evidence indicated that this was about 120 percent of planned production. 181/ The proportion of phenolics was estimated from a report that production was 1,500 percent of the prewar figure. 182/ The figure for 1937 (accepted as prewar) was 483 tons. 183/

Production was expected to be 400 grams per capita in 1954. 184/ The population was about 27 million* 185/; therefore, production of plastics in 1954 was about 11,000 tons. The proportion of phenolics was estimated.

Production was reported to be 15,800 tons in 1955. 186/ The proportion of phenolics was estimated. Production in 1960 is expected to amount to 1,700 to 1,800 grams per capita. 187/ On the basis of 1,750 grams per capita and an estimated population of 30 million, 52,500 tons will be produced. The proportions of phenolic and vinyl plastics were estimated on the basis of a report that 60 percent of production in 1960 would consist of phenolic and amino plastics and 34.7 percent, of vinyl plastics. 188/

2. Value of Production.

The methodology for deriving the estimated value of production of plastics in the USSR in 1954 (in 1954 prices) was as follows:

One source gave the planned value of consumer goods made from plastics in 1954 as 370 million rubles. 189/ The cost of plastic components of finished articles in the field of communications was reported to be 20 to 30 percent of the over-all cost of the articles. 190/ Assuming that the plastic components of the consumer goods mentioned comprised about 25 percent of the total value (as they do in the field of communications), the value of plastics going into consumer goods in 1954 would have been 92.5 million rubles. The estimate is subject to a considerable range of error.

A table indicating the allocation by economic use of plastics and plastic articles shows that 14 percent by value of all plastics produced by the Soviet chemical industry went into consumer goods and 86 percent by value went into producer goods. The table also shows that 67 percent by value of total production of plastics was in the form of chemical raw materials and 33 percent by value, in the form of finished articles. 191/

* Estimated from the figure of 26.5 million for 1953.

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The value of total production of plastics in the USSR in 1954 was estimated at 661 million rubles, and this figure was then broken down to show the value of plastics in the form of chemical raw materials and in the form of finished articles.

The methodology for deriving the estimated value of total production of chemicals in the USSR in 1955 was as follows:

The estimate is in terms of "branch commodity production," which, in Soviet terminology, is total production of a commodity less the amount used within the industry. The estimate is subject to a considerable range of error.

Ninety percent of production of the Ministry of the Chemical Industry consists of producer goods, and 10 percent consists of consumer goods. 192/ Fifteen percent of branch commodity production of producer goods by the Ministry of the Chemical Industry in 1955 was earmarked for agriculture, exclusive of sales to agriculture of chemicals and chemical end products relating to machinery or equipment, such as tires. 193/ It is estimated that fertilizers accounted for 10 percent of branch commodity production of producer goods. The value of mineral fertilizers produced by the Ministry of the Chemical Industry in 1955 has been estimated at about 1.5 billion rubles (in prices of July 1955). 194/ Branch commodity production of the Ministry of the Chemical Industry was estimated at 17 billion rubles. Because the Ministry of the Chemical Industry accounts for about 80 percent of total production of chemicals in the USSR, 195/ the total value of chemical production in 1955 was estimated at 21 billion rubles.

The estimated value of Soviet production of chemicals in 1954, 20 billion rubles, is based on the estimated value of production of chemicals in 1955. Prices were higher in 1954 than in 1955 and are believed to compensate roughly for lower production in 1954.

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APPENDIX C

GAPS IN INTELLIGENCE

Direct information on production and distribution of vinyl and phenolic resins in the Soviet Bloc is scarce, with the exception of data on production of polyvinyl chloride in East Germany.

One of the difficulties encountered in interpreting data on plastics was the variety of meanings given to the term itself. In some reports the term plastics denoted plastic materials; in others, it denoted fabricated plastics; and sometimes it included both concepts. Often no further clarification was possible.

The lack of reliable plant data was particularly pronounced for the USSR and the European Satellites, exclusive of East Germany. Data on plants in the USSR were obtained from German prisoners of war who were later released by the USSR. Most of these prisoners had little or no technical qualifications and were poor observers. Moreover, Soviet security precautions often prevented the Germans from entering strategic buildings. By 1950, most of the German prisoners of war were repatriated or moved to areas not connected with the plastics industry, so that little recent information of any kind is available from these sources.

The most serious gaps in intelligence are listed below:

1. Production.

a. USSR.

(1) Actual production of plastics, with breakdown by types, in 1945 and later years.

(2) Production of polyvinyl chloride at Plant No. 91, Beketovka, and Plant No. 96, Dzerzhinsk, in 1950-55.

(3) Production of vinyl resins at the Yerevan Polyvinyl Acetate Plant in 1953 and later years.

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(4) Production of phenolic resins in 1950-55 at the following plants:

Plant Karbolit, Orekhovo-Zuyevo
Plant Karbolit, Kemerovo
Okhta Chemical Combine, Leningrad
Plant No. 96, Dzerzhinsk
Plant No. 154, Vladimir

b. East Germany.

(1) Total production of plastics in 1954 and later years.

(2) Production of phenolic resins in 1954 and later years at the following plants:

VEB Kunstharz und Pressmassefabrik, Erkner
VEB Kunstharz und Pressmassefabrik, Espenhain
VEB Leuna Werke "Walter Ulbricht"

c. Other Satellites.

(1) Location, production, and capacity of plants producing phenolic resins.

(2) Production of polyvinyl chloride in Poland and Czechoslovakia in 1953 and later years.

2. Trade.

a. Intra-Bloc trade in vinyl and phenolic resins, including data on prices, in 1954 and later years.

b. Actual imports of vinyl and phenolic resins into the Soviet Bloc from the West in 1953 and later years.

c. Exports of vinyl and phenolic resins or articles from the Soviet Bloc to the West.

3. Consumption and Distribution.

a. Actual consumption of phenol, formaldehyde, carbide, and chlorine used in production of plastics in the Soviet Bloc.

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b. Internal distribution of vinyl and phenolic resins and finished articles, showing consumer, industrial, and military end-use patterns.

c. Consumption of plastics per capita in the USSR and in East Germany.

4. Capital Investment.

Planned or actual investment in the plastics industry in the Soviet Bloc in 1950 and later years.

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APPENDIX D

SOURCE REFERENCES

Documentary sources were the most valuable in providing data on production in the USSR and East Germany. The most reliable information on the USSR came from official annual Plans or Five Year Plans and from official technical journals, particularly Khimicheskaya promyshlennost'. The most reliable information on East Germany came from documents prepared by German statisticians. Reports on Plans or fulfillment of Plans gave the most reliable information on production in the other European Satellites.

Nondocumentary reports contained useful information on developmental plans and on the initiation of production at new plants.

Technical periodicals and press and radio statements contained useful information on the plastics industry in the Soviet Bloc, providing some data on consumption per capita and useful statistics on the Polish and Czechoslovak plastics industries.

State Department documents were useful in supplying information on trade in the Soviet Bloc and COCOM documents, in providing reports of attempts by the Bloc to obtain equipment and technology for its plastics industries from the West.

Most of the reports prepared from interrogations of defectors and former prisoners of war were of little value, although such reports helped to identify producing plants and occasionally provided pertinent information on inputs of raw materials.

Evaluations, following the classification entry and designated "Eval.," have the following significance:

- 49 -

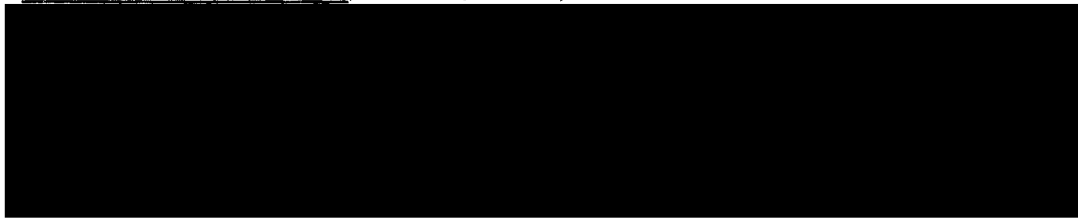
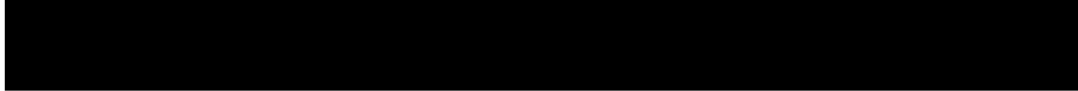
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<u>Source of Information</u>	<u>Information</u>
Doc. - Documentary	1 - Confirmed by other sources
A - Completely reliable	2 - Probably true
B - Usually reliable	3 - Possibly true
C - Fairly reliable	4 - Doubtful
D - Not usually reliable	5 - Probably false
E - Not reliable	6 - Cannot be judged
F - Cannot be judged	

"Documentary" refers to original documents of foreign governments and organizations; copies or translations of such documents by a staff officer; or information extracted from such documents by a staff officer, all of which may carry the field evaluation "Documentary."

Evaluations not otherwise designated are those appearing on the cited document; those designated "RR" are by the author of this report. No "RR" evaluation is given when the author agrees with the evaluation on the cited document.

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56. [REDACTED]
57. [REDACTED]
58. [REDACTED]
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